# Genetic variability and path coefficient analysis in sweet basil for oil yield and its components under organic agriculture conditions

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**Abstract:** Data for variability, heritability, genetic advance and path coefficient analysis for oil yield and related characters were conducted on 15 genotypes of sweet basil at two seasons in complete randomized block design. The results revealed that analysis of variance showed highly significant differences among genotypes in studied characters. Ranges of herb dry yield (HDY) (68.40 – 86.30 gm.), oil content (2.30-2.90 ml.) and oil yield (1.22-2.24 ml.) were obtained. Overall, the highest values of genotypic coefficients of variation (G .C. V %), genetic advance (GA%), and broad sense heritability ($h^2b$) were obtained for stem dry weight (SDW), linear growth (LG), herb dry weight (HDW) and leaf dry weight (LDW). Path coefficient analysis for oil yield exhibited variation from season to other and slight variation was found among cuts. The highest direct effects on oil yield were observed for herb dry yield followed by stem dry weight and essential oil content; hence, the study reflected the importance of herb dry yield and essential oil content as selection criteria for improvement of oil yield in sweet basil.

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## 1. Introduction

The genus *Ocimum* L. (*Lamiaceae*), collectively called basil comprises 30-160 annual and perennial herbs and shrubs native to tropical and subtropical regions of Asia, Africa and Center & South America, Paton 1996.

Sweet basil, *Ocimum basillcum* L., is well known for its numerous economical, medicinal and aromatic values (Simon *et al.*, 1990) and (Morales and Simon, 1996*)*. Medicinally, it is useful in a variety of human and animal diseases treatment such malaria, colic, vomiting, common cold, cough and skin diseases, (Bhattacharier, 1998). The importance of basil is increasing and has promising future in Egypt, especially, when cultivated in new reclaimed soil under organic agriculture conditions (Abd-El Raouf 2001, and Aboud *et al*., 2006). Genetic improvement in aromatic plants for quantitative characters is helpful for determination of yield components to improve oil yield through selection of genotypes from population Kazmferezak, *et al.*, 2001 and Seidkr-Ozykowska *et al.*, 2001.

Genetic parameters estimating (PCV, GCV, $h^2b$ and GA) are important to determined genetic variability among selected genotypes of different species of basil, De Masi *et al.*, 2005 and Nurzynska-Wierdak 2007.

Oil yield is a quantitative trait and highly influenced by many genetic factors and environmental fluctuation. In a plant breeding program, direct selection for yield as such can be misleading. Path coefficients provide a better understanding of association of different characters with yield. (Singh, 1990*;* Singh *et al.*, 1998 and Yadav, 2007).

The objectives of this study are to determine the variation and genetic interrelationships among herb yield components of basil using genetic parameters and path coefficient analysis.

## 2. Materials and Methods

The present study was carried out during two successive growth seasons of 2009 and 2010 at the farm of South Tahrir Agric. Company, El-Bohira governorate. Fifteen sweet basil genotypes seeds (variety Grand Verde) selected and sown in bed on 25 March in both seasons.

35 days later from planting, seedlings were transplanted into field in 1 May 2009 and 2010. All plants were fertilized at rate of $35m^3$/ fed by organic manure without any chemical nutrient addition. The plants were harvested 2 times (Cuts) during July and September in both seasons. Data recorded on of the 15 genotypes from each replicate in both cuts for seven growth herb characters included: Linear

growth (LG), Number of primary branches (NPB), Leaves dry weight (LDW), stem dry weight (SDW), Herb dry weight (HDW), Essential oil content % (EOC) and Essential oil yield (EOY).

A complete randomized block design with three replications was used in the experiment, the general statistical procedures was practiced according to Steel and Torrie, (1980). Analysis of variance (ANOVA) and broad sense heritability ($h^2b$) were generally assigned for the data of each season according to Robinson *et al* (1951). The phenotypic coefficient of variation (PCV %) were computed according to Burton and Dorane (1953). The expected genetic advance from selection (Δ GA %) was computed according to Johanson *et al*, (1955). Path coefficient analysis was performed as illustrated by Singh and Chaudhary (1979), to partition correlation between the characters studied into direct and indirect effects.

Essential oil content in air dried herb was extracted and determined on basis of volume / weight X 100. (Guenther (1972) Oil yield was calculated from multiplication of leaves dry weight gm. /plant X essential oil % content.

## 3. Results

### Genetic variations

The variations displayed by the seven characters studied in sweet basil at two successive seasons in the two cuts among fifteen genotypes are shown in table (1). Genotypes differed significantly in all studied characters. The highest coefficients of variation ranged from 15-20 % and shown by stem dry weight SDW, oil yield EOY, and oil content EOC at the two seasons, (Tables 2 and 3). Data presented in Tables 3 and 4 indicated the narrow range in essential oil yield EOY (2.30-2.90) in both seasons, cuts and also in NPB (13.80-17.602), LDW (35.14-41.17) and stem dry weight SDW (20.80-27.13) respectively. While in case of linear growth LG, wide ranges were observed in both seasons and cuts. The phenotypic coefficient of variation PCV, genotypic coefficient of variation GCV estimates, broad-sense heritability ($h^2b$) and genetic advance GA are also shown in tables (2) and (3). The PCV was generally higher than the GCV for all the characters, but it many cases, the values of PCV and GCV differed only slightly. PCV and GCV ranged from (5.638-21.347) and (5.092-17.578) in both seasons and cuts. The heritability estimates ranges from 81.66% to 97.50% for LDW and SDW at first season in both cults respectively. While in the second season it was ranged from 86.37 to 97.14% for HDW and EOC. High heritability estimates were also shown for other characters in both seasons and cuts. The expected genetic advance, expressed on a percentage of the mean, varied from (4.159) in the 2nd cut to (10.313) in the 1st cut for SDW and LG respectively in the second season. Genetic advance was the highest in LG (11.99) and lowest value in NPB (1.35) at the first season.

### Path coefficient analysis

The direct and indirect effects of the seven herb growth characters and oil yield are presented in Tables (4) and (5) at two seasons over two cuts. The direct effect of (LG) Linear growth was negative and moderate (-0.3122) in the 2nd season at the first cut but it was low for linear growth was (-0.1015) at the first season on the first cut. Low positive value was observed in the 2nd cut (0.0247) at the first season. The lowest values for linear growth showed in case of indirect effects were of (LG) via LDW at both seasons. High and moderate indirect effects were observed for (LG) via HDW (0.51531, 0.3772) and (0.2505; 0.3168) at first and second cults of both seasons.

Comparing the results of path coefficient analysis for (NPB), the direct effect was negative in all cuts with small values except in case of first cut at second season (0.0303) it was positive.

High indirect effect was observed in (NPB) via EOC (0.6567) at second cut in the first season, but in other cults in both seasons, moderate values (0.3824), (0.3086) and (0.244) were observed in this characters via EOC at first, first and second cults respectively in both seasons. The lowest values of (NBP) via LDW (0.0003) at second season in second cut indirectly. The remaining indirect effects for this trait were ranged from low to very low values in both seasons Leaf dry weight (LDW) revealed that high indirect effect (0.5962) on oil yield via EOC at the second cut on the first season. The direct effect of (LDW) (-0.0748), (-0.1121) at first season were negative with low values in case of first and second cuts except in first cut at second season, positive affect was recorded (0.1381). The lowest values of (LDW) (0.0006) (0.0088) were estimated through LG and NPB in both cults and seasons.

The direct effect of (SDW) ranged from very low positive (0.0051), (0.0310) to low negative values (-0.0348, -0.0412) at second and first cuts for both seasons. High to moderate indirect effects were detected through HDW (0.6503), (0.4246) and (0.4331) , (0.3486) at first and second cuts in both seasons, for (SDW) the indirect effect via EOC was moderate positive value in the first season (0.1801), (0.2011) at first and second cuts respectively. On the other hand negative low values were observed at second season in both cuts, via LDW (-0.0245) (-0.0341) indirectly. The (HDW) had the highest positive direct effect on oil yield on both seasons and cults (0.6925) vs. (0.5806) and (0.5001) vs. ((0.4363) first cut and second cut on both seasons respectively. moderate values via EOC at the first and second seasons on both cults except in case of indirect effect of this trait (HDW) through the same character which was very low value (0.0.0008).

Essential oil content (EOC) showed the highest direct effects on oil yield in the both seasons. The values of direct effects were (0.9033) followed

The indirect effects of (HDW) were positive

by (0.8404), (0.7793) and (0.5507) in second and first cuts in both seasons respectively. The indirect effects of (EOC) were ranged from low positive values to very low negative through each of HDW and LDW, Tables 4 and 5.

Table 1. Mean squares of seven characters studied in two cuts and two successive seasons of fifteen basil genotypes.

| | | Characters | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Seasons | Cuts | LG | LDW | NBP | SDW | HDw | EOC | EOY |
| First season | 1st cut | 128.972** | 1.193** | 12.386 | 45.339** | 92.645** | 0.313** | 0.181** |
| | 2nd cut | 214.038** | 2.924** | 12.751** | 10.302** | 84.107** | 0.208** | 0.199** |
| Second season | 1st cut | 150.100** | 3.344** | 28.713** | 72.430** | 132.921** | 0.411** | 0.378** |
| | 2nd cut | 150.100** | 4.646** | 34.539** | 25.426** | 67.190** | 0.216** | 0.191** |

*P < 0.05; **P < 0.01; ***P < 0.001

Linear growth (**LG)**, Number of primary branches (**NPB)**, Leaves dry weight (**LDW**), stem dry weight (**SDW**), Herb dry weight (**HDW)**, Essential oil content % (**EOC) and** Essential oil yield (**EOY**).

Table 2. Mean, range, coefficient of variation, phenotypic coefficient of variation, genotypic coefficient of variation, broad sense heritability and expected genetic advance for seven characters in two cuts, of fifteen basil genotypes in the first season.

| Characters | Cuts | Mean ±S.E. | Range (R) | Coefficient of variation C.V% | Phenotypic of variation P.C.V% | Genotypic of variation G.C.V% | Heritability $h^2b$ % | Genetic advance GA% |
|---|---|---|---|---|---|---|---|---|
| LG | I | 76.82±1.530 | 65.70-86.20 | 8.535 | 8.765 | 4.418 | 92.25 | 9.228 |
| | II | 84.52±1.68 | 70.14-98.50 | 9.993 | 10.192 | 9.895 | 94.24 | 11.99 |
| NPB | I | 11.50±0.258 | 10.40-12.50 | 5.483 | 5.831 | 5.301 | 82.66 | 0.0845 |
| | II | 15.49±0.307 | 14.80-17.20 | 6.373 | 6.676 | 6.217 | 86.72 | 1.352 |
| LDW | I | 27.40±0.546 | 24.62-31.16 | 7.421 | 7.679 | 7.280 | 89.88 | 2.827 |
| | II | 39.03±0.770 | 35.14-41.17 | 5.282 | 5.638 | 5.95 | 81.66 | 2.746 |
| SDW | I | 24.97±0.505 | 20.12-31.16 | 15.573 | 12.698 | 15.502 | 97.50 | 5.603 |
| | II | 28.38±0.466 | 20.80-27.13 | 7.926 | 6.733 | 6.425 | 91.07 | 2.594 |
| HDW | I | 62.83±1.257 | 55.67-74.15 | 8.854 | 9.124 | 8.702 | 90.96 | 7.838 |
| | II | 76.42±1.517 | 68.40-86.30 | 6.928 | 7.207 | 6.785 | 88.62 | 7.322 |
| EOC | I | 2.60±0.053 | 2.30-2.90 | 12.420 | 12.581 | 12.344 | 96.26 | 0.463 |
| | II | 2.35±0.047 | 1.80-2.80 | 11.124 | 11.365 | 11.120 | 95.79 | 0.373 |
| EOY | I | 1.63±0.032 | 1.32-2.15 | 15.041 | 15.235 | 14.685 | 96.76 | 0.354 |
| | II | 1.80±0.037 | 1.51-2.07 | 14.296 | 14.452 | 14.236 | 97.04 | 0.370 |

Linear Growth (**LG)**, Number of Primary Branches (**NPB)**, Leaves Dry Weight **(LDW**), Stem Dry Weight (**SDW**), Herb Dry Weight (**HDW)**, Essential Oil Content % (**EOC)** and Essential Oil Yield (**EOY**).

Table 3. Mean, range, coefficient of variation, phenotypic coefficient of variation, genotypic coefficient of variation, broad sense heritability and expected genetic advance for seven characters in two cuts of fifteen basil genotypes at the second season.

| Characters | Cuts | Mean ±S.E. | Range (R) | Coefficient of variation C.V% | Phenotypic of variation P.C.V% | Genotypic of variation G.C.V% | Heritability $h^2b$ % | Genetic advance GA% |
|---|---|---|---|---|---|---|---|---|
| LG | I | 81.93±1.76 | 69.80-92.40 | 8.634 | 8.857 | 8.520 | 92.52 | 9.968 |
| | II | 86.81±1.83 | 77.40-96.18 | 8.447 | 8.679 | 8.329 | 92.09 | 10.313 |
| NPB | I | 10.75±0.264 | 8.70-12.20 | 9.844 | 10.022 | 9.719 | 94.06 | 1.499 |
| | II | 15.54±0.310 | 13.80-17.80 | 8.00 | 8.254 | 7.882 | 91.19 | 1.742 |
| LDW | I | 31.09±0.772 | 26.14-36.12 | 9.950 | 10.148 | 9.850 | 94.23 | 4.394 |
| | II | 40.0±0.158 | 32.17-45.14 | 8.480 | 8.705 | 8.369 | 92.24 | 4.779 |
| SDW | I | 27.86±1.23 | 18.24-31.14 | 17.64 | 20.880 | 17.578 | 98.04 | 7.098 |
| | II | 30.84±0.726 | 22.14-33.20 | 11.27 | 9.585 | 9.366 | 95.47 | 4.159 |
| HDW | I | 65.92±1.66 | 53.14-78.13 | 10.09 | 10.293 | 9.998 | 94.35 | 9.460 |
| | II | 75.53±1.180 | 96.58-85.92 | 5.27 | 6.571 | 6.107 | 86.37 | 6.469 |
| EOC | I | 2.45±0.092 | 1.90-3.00 | 15.084 | 15.254 | 15.034 | 97.14 | 0.533 |
| | II | 2.43±0.067 | 1.90-2.80 | 11.064 | 11.245 | 10.939 | 94.64 | 0.383 |
| EOY | I | 1.67±0.089 | 1.22-2.29 | 21.238 | 21.367 | 21.199 | 98.92 | 0.514 |
| | II | 1.84±0.063 | 1.36-2.23 | 13.750 | 13.856 | 13.641 | 96.92 | 0.363 |

Linear growth (**LG**), Number of primary branches (**NPB**), Leaves dry weight (**LDW**), stem dry weight (**SDW**), Herb dry weight (**HDW**), Essential oil content % (**EOC**) and Essential oil yield (**EOY**).

Table 4. Path coefficient values estimate for oil yield and other seven characters in two cuts in the first season of basil genotypes.

| Pathway of association | Values estimated in | |
|---|---|---|
| | 1st cut | 2nd cut |
| 1-Oil yield vs Linear growth | | |
| Direct effect | -0.1015 | 0.0247 |
| Indirect effect via (X2) | 0.0368 | -0.0151 |
| Indirect effect via (X3) | 0.0004 | -0.0026 |
| Indirect effect via (X4) | -0.0245 | 0.0062 |
| Indirect effect via (X5) | -0.5153 | 0.2505 |
| Indirect effect via (X6) | -0.1748 | -0.1382 |
| Total effect | 0.2517 | 0.1255 |
| 2- Oil yield vs Number of primary branches | | |
| Direct effect | -0.0841 | -0.1008 |
| Indirect effect via (X1) | 0.0443 | 0.0037 |
| Indirect effect via (X3) | 0.0079 | -0.0257 |
| Indirect effect via (X4) | 0.0110 | 0.0032 |
| Indirect effect via (X5) | -0.2119 | 0.1540 |
| Indirect effect via (X6) | -0.3824 | 0.6567 |
| Total effect | 0.1338 | 0.6912 |
| 3- Oil yield vs Leaf dry weight | | |
| Direct effect | -0.0748 | -0.1121 |
| Indirect effect via (X1) | 0.0006 | 0.0006 |
| Indirect effect via (X2) | -0.0089 | -0.0231 |
| Indirect effect via (X4) | -0.0114 | 0.0028 |
| Indirect effect via (X5) | -0.3414 | 0.1655 |
| Indirect effect via (X6) | 0.2244 | 0.5962 |
| Total effect | 0.4713 | 0.6299 |

Table 4. Continue.

| Pathway of association | Values estimated in | |
|---|---|---|
| | 1st cut | 2nd cut |
| 4 Oil yield vs Stem dry weight | | |
| Direct effect | -0.0348 | 0.0091 |
| Indirect effect via (X1) | -0.0713 | 0.0167 |
| Indirect effect via (X2) | 0.0267 | -0.0351 |
| Indirect effect via (X3) | -0.0245 | -0.0341 |
| Indirect effect via (X5) | -0.6503 | 0.4246 |
| Indirect effect via (X6) | -0.0513 | 0.1743 |
| Total effect | 0.4951 | 0.5556 |
| 5- Oil yield vs Herb dry weight | | |
| Direct effect | 0.6925 | 0.5001 |
| Indirect effect via (X1) | -0.0755 | 0.0124 |
| Indirect effect via (X3) | 0.0257 | -0.0310 |
| Indirect effect via (X4) | -0.0369 | -0.0371 |
| Indirect effect via (X5) | 0.0327 | 0.0078 |
| Indirect effect via (X6) | 0.0008 | 0.2105 |
| Total effect | 0.5741 | 0.6625 |
| 6- Oil yield vs Essential oil content | | |
| Direct effect | 0.8404 | 0.9033 |
| Indirect effect via (X1) | 0.0211 | -0.0038 |
| Indirect effect via (X2) | -0.383 | -0.0733 |
| Indirect effect via (X3) | -0.0200 | -0.0740 |
| Indirect effect via (X4) | 0.0021 | 0.0018 |
| Indirect effect via (X5) | 0.0007 | 0.1165 |
| Total effect | 0.8061 | 0.8706 |

Table 5. Path coefficient values estimate for oil yield and other characters in two cuts in the second season of basil genotypes.

| Pathway of association | Values estimated in | |
|---|---|---|
| | 1st cut | 2nd cut |
| 1- Oil yield vs Linear growth | | |
| Direct effect | -0.3122 | -0.0095 |
| Indirect effect via (X2) | -0.0116 | -0.0048 |
| Indirect effect via (X3) | -0.0105 | -0.0036 |
| Indirect effect via (X4) | -0.188 | 0.0167 |
| Indirect effect via (X5) | -0.3379 | 0.3168 |
| Indirect effect via (X6) | -0.1355 | -0.1262 |
| Total effect | -0.1506 | 0.1893 |
| 2- Oil yield vs Number of primary branches | | |
| Direct effect | 0.0303 | -0.0188 |
| Indirect effect via (X1) | 0.1196 | -0.0024 |
| Indirect effect via (X3) | 0.0402 | 0.0003 |
| Indirect effect via (X4) | 0.0126 | 0.0001 |
| Indirect effect via (X5) | -0.1510 | 0.0681 |
| Indirect effect via (X6) | 0.2544 | 0.3086 |
| Total effect | 0.3062 | 0.3558 |
| 3- Oil yield vs Leaf dry weight | | |
| Direct effect | 0.1381 | -0.0080 |
| Indirect effect via (X1) | 0.0237 | -0.0043 |
| Indirect effect via (X2) | 0.0088 | 0.0006 |
| Indirect effect via (X4) | 0.0037 | 0.0132 |
| Indirect effect via (X5) | 0.1840 | 0.2893 |
| Indirect effect via (X6) | 0.2319 | -0.0764 |
| Total effect | 0.5909 | 0.2145 |

Table 5. Continue.

| Pathway of association | Values estimated in | |
|---|---|---|
| | 1st cut | 2nd cut |
| 4- Oil yield vs. Stem dry weight | | |
| Direct effect | - 0.0412 | 0.0310 |
| Indirect effect via (X1) | -0.1423 | -0.0051 |
| Indirect effect via (X2) | -0.0093 | -0.0001 |
| Indirect effect via (X3) | -0.126 | -0.0034 |
| Indirect effect via (X5) | -0.4331 | 0.3486 |
| Indirect effect via (X6) | -0.2087 | 0.0990 |
| Total effect | 0.4365 | 0.4700 |
| 5- Oil yield vs Herb dry weight | | |
| Direct effect | 0.5806 | 0.4363 |
| Indirect effect via (X1) | -0.1817 | -0.0069 |
| Indirect effect via (X2) | -0.0079 | -0.0029 |
| Indirect effect via (X3) | 0.0439 | -0.0053 |
| Indirect effect via (X4) | -0.03070 | 0.0248 |
| Indirect effect via (X6) | 0.1801 | 0.2011 |
| Total effect | 0.543 | 0.6470 |
| 6- Oil yield vs Essential oil content | | |
| Direct effect | 0.5507 | 0.7793 |
| Indirect effect via (X1) | 0.0768 | 0.0015 |
| Indirect effect via (X2) | 0.0140 | -0.0074 |
| Indirect effect via (X3) | 0.0581 | 0.0008 |
| Indirect effect via (X4) | -0.0156 | 0.0039 |
| Indirect effect via (X5) | 0.1899 | 0.1126 |
| Total effect | 0.8739 | 0.8907 |

**4. Discussions**

The breeding strategies are mainly oriented toward yield and oil yield in aromatic crops. The success of the breeding program depends on the variability of initial material, Fick and Miller, (1997). In order to apply on optimum breeding strategy for targeted quantities characters, genetic analysis of these traits, need to perform. (Has 1999*, and* Nistor *et al.*, 2005).

Analysis of variance showed that genotypes of basil differed significantly among themselves for all studied characters in both seasons. The presence of wide variations among genotypes indicated that these traits were governed by additive genes with low environmental effects. Similar results were obtained by Aboud, 2006.

The results of ranges of studied characters showed narrow ranges in essential oil content, oil yield, No. of primary branches and leaf dry weight but in case of linear growth (LG) wide range between means of genotypes are observed in generations and cuts. The wide range of this trait could be due to the large sample size of population, therefore, the higher proportion of phenotypic variance observed on this trait Miller *et al* (1957). From (P.C.V) and (G.C.V) estimates, for studied characters, suggested that, (PCV) was generally higher than (GCV) for all characters except in some traits, (PCV) and (GCV) differed slightly. The highest values of (P.C.V) and (PCV) were obtained for stem dry weight, oil content, oil yield and linear growth (LG) in both seasons. Genotypic coefficient of variation (GCV) indicates the genetic variability with heritability estimates would give best indication for the amount of gain due to selection Johanson *et al* (1955). Heritability estimates were high for most studied characters. Highest broad sense heritability values for stem dry weight (SDW) and herb dry weight (HDW) indicated that selection for these characters under organic agriculture conditions may be effective in breeding programs. Similar results are accordance with results of Singh, (1990), and Ibrahim, (2006).

The expected genetic advance (GA) ranged from 4.159 to 10.313 in stem dry weight (SDW) and linear growth (LG) respectively in both seasons. Genetic advance (GA) and broad sense heritability ($h^2b$) estimates (Table 2 and 3) showed higher values by (LG), (SDW), (HDW) and oil content (EOC) that due to additive gene effect, therefore selection for these traits could predict the performance of the progenies. Blank *et al* (2004). Beside coefficient of variability and heritability, it is important to know the relationships between the yield component and oil yield by the path coefficient analysis Dewey and Lu (1959).

Path coefficient analysis of herb growth characters with oil yield in two cuts and two seasons was partitioned into direct and indirect effects (Tables 2, 3). The results revealed that herb dry weight (HDW) had maximum direct effect on oil yield followed by oil content and leaf dry weight. These results are in agreement with Baslma (2008), and Mijic *et al,* (2009). The direct effect of linear growth (LG), No. of primary branches (NPB), leaf dry weight (LDW) and stem dry weight (SDW), on oil yield had negative effects and ranged from moderate to low values in both seasons which suggested that the selection for these traits indirectly may be less effective on oil yield. The indirect effects through studied characters with oil yield were fluctuated from negative or positive and ranged from moderate, low and very low in both seasons.

## 5. Conclusion

In conclusion, the results obtained in this study revealed that (PCV), (GCV), ($h^2$b) and (GA %) had the highest values in case of (HDW), (SDW), (LDW) and (LG), respectively. The lowest values of these items were observed in (EOC), (EOY) and (NPB). The highest values of direct effects of path coefficient are shown in herb dry weight (HDW) and oil content (EOC). The indirect effects of oil yield through linear growth (LG) and stem dry weight (SDW) via (HDW) were high positive effect. Similar results were observed in (NPB) via (EOC) and (LDW) via (HDW). The strong direct effects on oil yield for above characters indicated that these traits can be used as selection criteria for increasing oil yield. The influence of other studied characters covered by the indirect effects on oil yield.

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